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ABSTRACT

This book is a revised edition of one of the products of a project, "Teaching Mathematics and Science Concepts, K-6, funded by the New York State Education Department. The project was a collaborative effort by mathematics and science education faculty at the State University of New York at Albany and representatives of eight school districts in the Greater Capital District area of New York State. This book contains lesson ideas that reflect the belief that science and mathematics are opposite sides of the same coin. The lessons incorporate concepts and processes from both subjects. Activities were chosen for this booklet if they met the following criteria: (1) they combined important mathematics and science in a single lesson; (2) had been tried out by classroom teachers and elementary school children; (3) involved "hands-on" activities; (4) used readily available, everyday materials; and (5) could be used as the basis for further activities. Each activity includes the procedure, needed materials, key concepts, skills and processes, background information, and extensions. Included is a list of free and inexpensive materials that have proved useful in teaching science and mathematics and contains everything needed for the activities in this booklet and more. The topics of geometry, shapes, the earth, measuring, counting, inclined planes, work, gravity, friction, observing, classifying, angles, dew point, probability, symmetry, variation in nature, metric system, data collecting, estimation, ratios, proportion, melting, freezing, graphs, inferring, patterns, feeding and locomotion of animals, adaptations in animals, volume, ground water, and water supply are presented. A section "Sources of Further Ideas" contains a brief list of professional journals, teacher idea/reference books, curriculum projects along with a list of useable junk. (KR)

SCHOOL SCIENCE AND MATHEMATICS ASSOCIATION
Classroom Activities Series - Number 2

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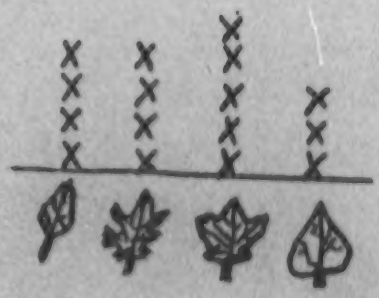
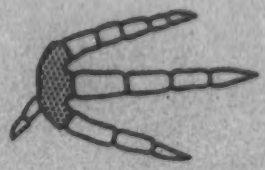
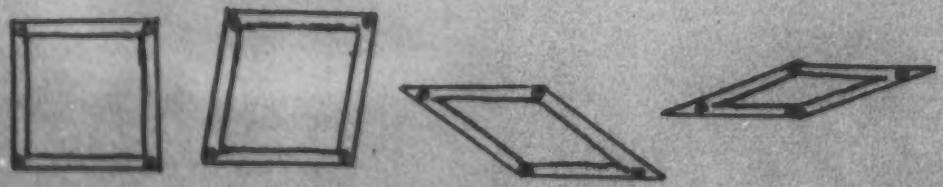
ACTIVITIES FOR TEACHING K-6 MATH/SCIENCE CONCEPTS

Walter A. Farmer and Margaret A. Farrell







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CLASSROOM ACTIVITIES SERIES
Number 2

ACTIVITIES FOR TEACHING K-6 MATH/SCIENCE CONCEPTS

Walter A. Farmer
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School Science and Mathematics Association
Spring, 1989

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PREFACE

This book is a revised edition of one of the final products of an inservice project, entitled **Teaching Mathematics and Science Concepts, K-6.** The project, funded by the New York State Education Department, was a collaborative effort by mathematics and science education faculty at the State University of New York at Albany and representatives of eight school districts in the Greater Capital District area of New York state.

Each teacher in the inservice project compiled a teaching resource file of at least sixty idea cards. One key source of these ideas was the series of demonstration lessons taught by the authors, other members of the mathematics and science education faculty of SUNYA, faculty from other colleges, and outstanding teachers and supervisors from area school districts. Other sources included the sourcebooks and journal articles to which the participants were referred by institute staff and consultants. Some teachers developed lesson ideas from their own creative imaginations.

As the resource files grew, each teacher taught lessons from his/her collection of ideas and shared that feedback with the authors. We were pleased by the the large number of enthusiastic comments such as "The kids loved it"; "The children didn't want to stop the activity when the buses came at the end of the day"; "They really did understand the concepts by the end of the lesson"; "I am much more confident about teaching science (math) now"; "I am learning a lot that I didn't know and enjoy teaching the ideas to my classes"; and "This lesson combined a lot of science and math and led nicely into a language arts activity." We were also delighted to hear reports of how teachers modified lesson ideas to make them more suitable for children with special needs and interests.

Part of the design of the institute was to share a number of these mathematics/science lesson ideas with non-participating elementary school teachers from the eight districts. Reproducing all 6,000 idea cards would have been an impossible task, as would reproducing the smaller number (still large !) remaining after duplicates had been removed. Thus we decided to write a resource book containing selected ideas for distribution to this wider audience.

How does one select from among so many good ideas? We chose activities that met the following criteria: (1) combined important mathematics and

science learnings in a single lesson, (2) had been tried out by classroom teachers and elementary school children, (3) involved "hands-on" activity, and (4) used readily available, everyday materials. In addition, we were particularly interested in activities that could be used as a basis for further lessons. Finally, we chose to provide a balance between K-3 and 4-6 grade levels, although ideas in either group can be adapted to meet the needs of the other grade levels. All the lessons that follow were modified as needed to meet these criteria. All were rewritten in a uniform format (Procedure, Materials, Key Concepts, Skills and Processes, Background, and Extensions) that we hope will be helpful to teachers and supervisors using these materials.

In the **Procedure** sections we included attention to the "how" as well as the "what," and did so in the amount of detail we judged would be needed by someone who had no experience with these particular activities. The **Materials** sections contain lists of all materials required to carry out the activities. In cases where alternative materials would serve the purpose, some of these are suggested. The **Key Concepts, Skills and Processes** sections were written with particular attention to contemporary syllabi for elementary mathematics and elementary science. The **Background** sections include information for the teacher who may have had little college preparation in mathematics (in particular, in topics like probability) and/or the natural sciences. Many of the teacher institute participants found that this kind of information helped them focus student attention on major lesson objectives. In the **Extensions** sections, we suggest one to several related activities for follow-up lessons. In some cases these may be used as the basis for individual student project work.

Some might wonder why we did not elect to cite a specific source at the end of each activity. Many of the ideas are "old [and marvelous] chestnuts" that we have seen used and/or described in several <u>different</u> publications over the years. The original source for these could not be determined. In a few instances where this was not the case, an original source is cited. A more important concern of practical use to classroom teachers who are not science or mathematics specialists was to include a guide that could be used to find additional sources of similar ideas. We have provided a " starter" list under the section heading, **Sources of Further Ideas.** If your school library doesn't have some of these on hand, you might share the list with the librarian for use when new acquisitions are being considered.

Many experienced teachers already have their own mental or written lists of *usable junk*. We have included our list of free and inexpensive materials (**Usable Junk**) that have proved useful in teaching science and mathematics. The list contains everything needed for the activities in this booklet and more.

Feedback from teachers using the original version of this resource book has been enthusiastic. Some college faculty have used it in inservice or graduate elementary education courses. They have commented favorably on the emphasis on mathematics and science to be found in each lesson. This revised edition of the original monograph differs from the original book in minor ways. It contains a few additional diagrams and minor stylistic and editorial changes.

We appreciate the interest of the School Science and Mathematics Association and are pleased that this teacher resource book will be published under their auspices.

Walter A. Farmer and Margaret A. Farrell January, 1989

Walter A. Farmer died at his home after a long illness on January 31, 1989. His last contribution to the profession he loved was the revision of this book. Walt was especially pleased that these teaching ideas would live on in the classrooms of elementary teachers. He personally added several new sketches to the activities in order to clarify ideas and helped to make this revision a useful and creative bank of ideas for the teacher. The profession of science education has been enriched by him. We will miss him.

Margaret A. Farrell

TO THE TEACHER

All of these lesson ideas reflect our firm belief that science and mathematics are opposite sides of the same coin. Teachers who have used these lessons find that because each lesson incorporates concepts and processes from both subjects, students learn more with less expenditure of total time. However, they also noted how important it was to convey to the students that they were learning mathematics and science. Children, not to mention their parents, are so accustomed to set periods of time being called mathematics or science, that interdisciplinary lessons sometimes lead to misunderstandings as to what is being taught.

For example, the intermediate lesson, ANIMAL TRACKS, may not sound like it incorporates any mathematics. However, the list of mathematics processes includes measuring, classifying and observing, as well as concepts of size and shape. It is important to help the children relate real world shapes to the ideal shapes of geometry -- the roughly triangular tracks of the raccoon's feet with the five toes or the almost circular track of the horse's hoof with the triangular indentation. In this way, the children are being helped to form an image so that they can remember the way certain tracks look, as well as get a firmer grasp of the characteristics of the ideal triangle or circle. But are classifying and observing part of mathematics? Definitely, yes! In the idea world, without the ability to classify, how would one decide that certain shapes were triangles, others squares, and so on. In the real world, observing patterns is one of the distinguishing traits of mathematicians and to identify a cluster of events as a pattern, different from some other cluster of events, is the essence of classifying. We encourage you to note the connections between the lesson components and the mathematics and science concepts and processes so that these are crystal clear to you.

Most important, try out each of the activities ahead of time and gain confidence that all will go as planned. Then have fun teaching meaningful mathematics/ science lessons via hands-on activities!

One caveat is essential. Each activity is identified as either K-3 or 4-6. This designation should be considered a general guideline only. Some K-3 activities are too advanced for kindergarten while others may not be challenging enough for an advanced group of third graders. The teacher is the person best able to make these kinds of judgments. We suggest that you examine all the lesson ideas and then select and adapt as appropriate.

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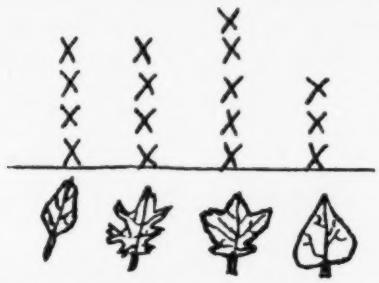
THE GEOMETRY OF LEAVES

Procedure: In the fall, have the children bring in 3 to 6 leaves, each of which is different from the other in shape (different kind). Each day have children place leaves on the floor and take turns separating them into different groups. Together count the number in each group and record these on the chalk board. Make a continuing bar graph of the number of leaf types found each day. Talk about the kind of leaf which shows up most, least. Discuss why. Look for the largest leaf, the smallest leaf, the leaves with the most points, the leaf with the most parts (compound), the type of leaf with the most variety of colors. Classify and name the most common leaves.



Laminate some of the leaves and cut out the outline for continued use. Have children see if any of the leaves can be folded so that the two parts match almost exactly (have bilateral symmetry).

Materials: Samples of each kind of leaf from trees common to the area. Illustrations adapted from Petrides' *Field Guide to Trees and Shrubs* . (These might be duplicated and the copies made into acetates. Then the acetates could be shown on an overhead projector in enlarged form.)

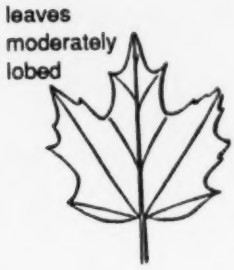
Key Concepts, Skills and Processes

Mathematics: Classification, counting, one-to-one correspondence, graphing, shape characteristics, bilateral symmetry, concepts of most, least.
Science: Classification, graphing, observing and concept of natural variation.

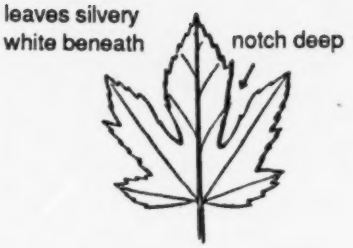
Background: Petrides' *Guide* is an excellent source for information on common leaves and reasons for variation on the same tree or two trees of the same type. It is important for students to begin to recognize that exact duplicates are never found in the natural world.

Extensions: Repeat this activity in the late spring. Have children bring in leaves and match these late-spring leaves to the colorful fall leaves from the same types of trees.

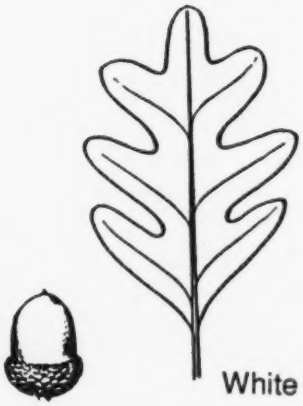
SIMPLE LEAF



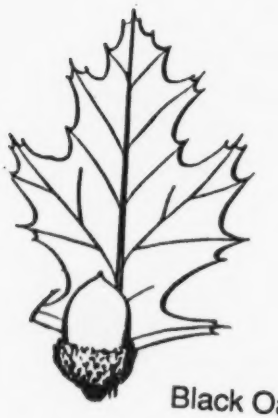
Sugar Maple



Silver Maple



White Oak



Black Oak

COMPOUND LEAF

Horsechestnut

American Mountain-Ash

APPLE MODEL OF EARTH

Procedure: Hold up a large, round-shaped apple and ask the youngsters to describe its shape. Then ask what geometric shape is the closest match to that of the apple. Tell them you are going to cut down through the apple right next to the stem and ask for a description of what the inside will look like when it is cut in half. Cut several apples in half and pass around for the students to observe as you question them about how much of the apple is skin versus core versus the fleshy part (between the skin and core).

Tell the children that the apple is a fairly good model of what scientists believe our planet Earth is like. The very thin outer layer of apple skin is like the Earth's crust--the part we live on and see -- which is made up of soil, rocks and bodies of water such as oceans, lakes and rivers. It is a very tiny amount compared to the total amount of material of the entire planet. Yet the deepest holes scientists have been able to drill have not reached the next inner layer, which is called the mantle. By using scientific instruments scientists have collected evidence that the mantle is so hot that some of the rocks melt and become like Silly Putty or Plasticine (Demonstrate these and/or pass some around.). The core is also thought to be so hot that many of the rocks become liquid, like water and milk. The rocks in the core are believed to be made up of iron and nickel for the most part (Show the class some nickels and objects made of iron.).

Ask the children to list ways in which the apple is not an exact model (copy) of what the inside of our planet is like (e.g. seeds, color, hardness). Remind them that no model is exact but we use models to help us get a picture in our minds. Invite them to suggest some better models we could make in the classroom. Have a variety of likely materials on hand and suggest the need for the use of some reference books containing sketches and diagrams before starting project work.

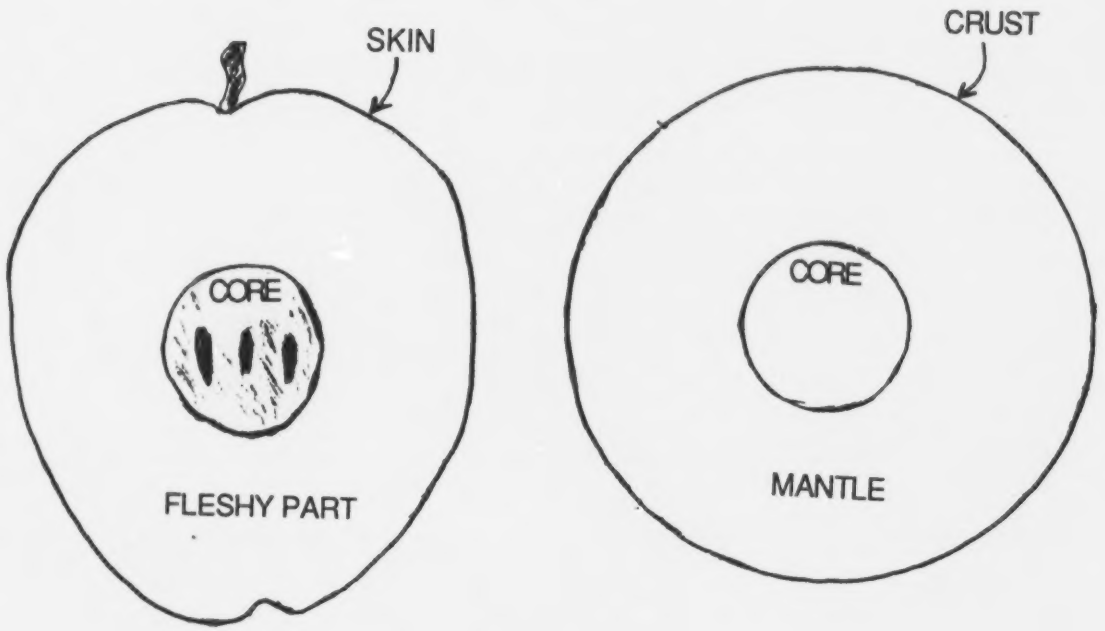
Materials: Apples, poster paper, styrofoam balls, modeling clay, magic markers, crayons.

Key Concepts, Skills and Processes

Mathematics: Concepts of geometric shapes (especially sphere) and mathematical model; processes of measuring and estimating.
Science: Same as above; also concepts of layers of the Earth and melting.

Background: One of the ways scientists have gathered evidence about the interior of the Earth is by studying the paths of earthquake waves with instruments called seismographs. The interior structure is more complex than presented in this lesson (e.g., solid inner core within the liquid outer core, moho or boundary between the crust and mantle) but those details should be left for the junior/senior high years. The concept of a mathematical model is used by both scientists and mathematicians to help explain real world phenomena. This concept is also a sophisticated idea, but one that can be approached at a naive level in the early grades. No mathematical model is ever a one-to-one match for a real world phenomenon. Students may need help in identifying the ways in which a model resembles, and does not resemble, the real world situation.

Extensions: Depending on age, reading ability and interest levels, students may make fairly sophisticated models more or less to scale. Have students identify other real world phenomena which have a shape similar to a sphere or to other geometric solids. Keep a set of geometric solids on hand for reference and have students bring in pictures of real world phenomena which correspond to the models. Question them as to the ways in which the real world examples corresponding to the same model match and do not match the model and each other.



MEASURING BY COUNTING

Procedure: Prepare 10 cm, 15 cm, 20 cm strips of *computer paper edges.* Be sure that each of the equally long strips has the same number of holes. The strips can be reinforced by pasting them on colored paper of nearly the same length and width. Do not use the language of *cm* with the children. Have the children count the holes on the 3 kinds of strips. Instruct them to match several strips so that they will realize that all the equally long strips have the same number of holes. Then have the children label the strips by the total number of holes on a strip. Ask a child to help measure one or more of your fingers with an appropriate strip and show how the answer can be given by counting the number of holes.

Have each child trace his/her right hand. Have the children work in pairs and measure each finger and thumb on each other's right hand. Each child should write the measure (number of holes) on the appropriate finger in the sketch. Have the children compare results. Talk about the use of this non-standard measure, the lack of difference in results when using the different-sized strips for the same finger, etc....

Materials: Edges of pin-feed computer paper, colored heavy-duty construction paper.

Key Concepts, Skills and Processes

Mathematics: Use of a non-standard unit of measure; practice in the use of counts as a measure; rounding; estimation.
Science: Same as mathematics, and concepts of variation and similarity in human growth patterns.

Background: Counting is the only exact form of measurement when used to "measure" discrete objects -- i.e. the number of petals on a flower or the number of children. Use of counting to measure continuous lengths provides an estimate of the length. The concept of estimation needs to be emphasized by the use of phrases such as "a little longer than the 8 hole strip," or "almost as wide as the 12 hole strip." Since the child is measuring objects no longer than a particular strip, the problem of how to lay down the measuring strip more than once can be avoided at first. Since this activity is an early developmental measurement project, the emphasis is on the prerequisite skills of counting and laying down a length next to the object to be counted.

There will not be much variation for comparable fingers on a particular child's right and left hand. There will be a lot more variation between length of a particular finger (e.g., index finger) of different children. This is a good activity to introduce or emphasize the concept of variation in human growth patterns.

Extensions: Provide children with other small objects and ask them to measure (count) a dimension (e.g. length of a pencil, length of chalk, length of a chalkboard eraser,...).

Paste a vertical measuring strip on the board or wall. It should contain equal-sized rectangles about 3 cm in height and be higher than your tallest student. Have children count the number of rectangles from the floor to the top of a partner's head.

Have children compare their heights to that of Robert Wadlow, the tallest recorded person (Guiness Book of World Records, 1987). He was born in 1918. Here are his heights at ages similar to those of elementary school children.

Age in Years	5	8	9	10	11
Height to nearest cm	163	183	188	196	201

Mark his approximate height at an age similar to that of most of your children on the vertical counting strip. Have children estimate whether they would be taller or shorter than him, and by how much? Have them check. If two children of about the same height "stood" on one another's shoulders, would the top child be lower than, equal to, or above the top of Robert Wadlow's head?

Robert Wadlow's maximum height was 254 cm, which he reached at age 22. This real-world giant died during his 22nd year of life. Abnormal heights and corresponding abnormal weights often lead to severe health problems.

Example of a 10 cm strip, labeled as an 8 (hole) strip

LET'S SLIDE DOWN THE SLOPE

Procedure: Set up the demonstration so that all of the children can see it. Ask children to imagine that they are walking up a playground slide. If the plank (slide) is raised (demonstrate), will the child wearing dress shoes begin to slide backward before the child wearing sneakers? Why? Tell the children that they're going to see what properties affect sliding. Ask the children to make observations of the objects (shape, size, texture) Demonstrate how you will raise the plank until an object placed on it slides. Point to the location on the vertical meter stick that indicates the height of the plank when the sliding starts.

With a group of objects, ask students to predict those that are likely to slide first, last. Try one or two objects and discuss the results. Continue the trials and ask a student to mark (with sticky tape, stickers,...) the vertical meter stick at the point where the high end of the plank is when the object first begins to move. Have another student read the place on the meter stick that has been marked. (With young children, who would have trouble reading the meter stick, color code each object and use a sticker of that color to mark the meter stick. Then compare the sliding properties of a group of objects by looking at the colored sticker that is highest, lowest.). Record the data. Use student shoes with different soles (leather versus sponge, different patterns on sneakers,...).

Ask questions such as " What are the properties (size, shape, texture) of the object? Which will move first, last? Why is it important to measure height? Why is it important to record the results? Does size make a difference? When? Why? Does shape make a difference? Which? Why? Do smooth objects move before rough objects? Do balls move before objects with flat sides? Are you sure? " Discuss. Graph the data and talk about the graph.

Materials: A plank about 15 cm wide and 1.0 to 1.5 m long; a meter stick held vertical by a clamp; a collection of objects of various sizes and shapes, such as round and hexagonal pencils, balls of different sizes, blocks of wood wrapped in sandpaper, aluminum foil, or wax paper, and students' shoes with different sole types ; sticky tape or stickers to mark the meter stick.

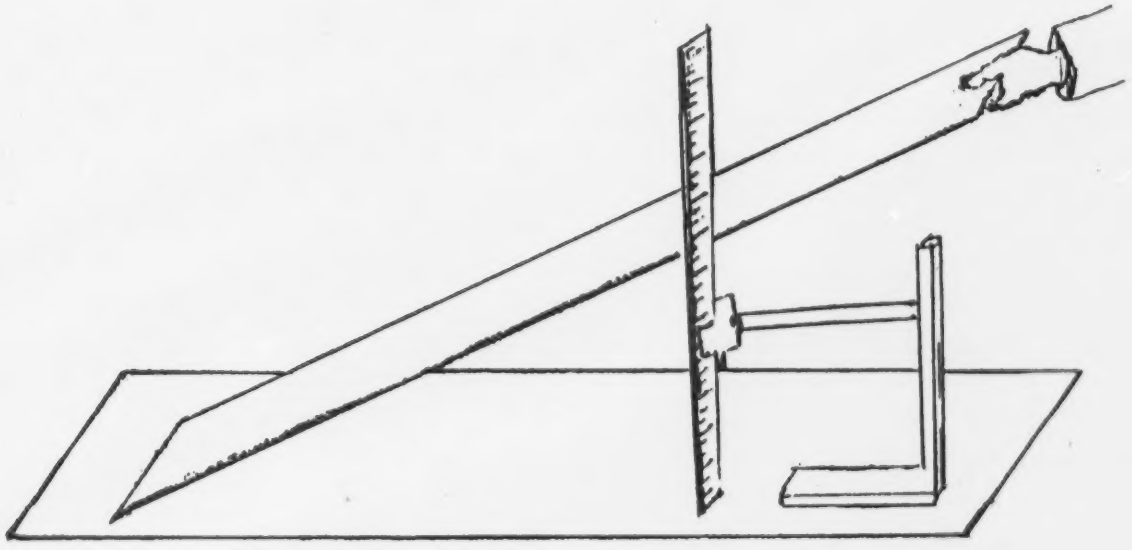
Key Concepts, Skills and Processes

Mathematics: Concepts of height, angle, and shape (round, flat, smooth,

edges, sphere, cube); processes of reading meter stick, observing, collecting, recording and analyzing data.
Science: All of the processes above and also predicting; concepts of inclined plane, work, gravity and friction.

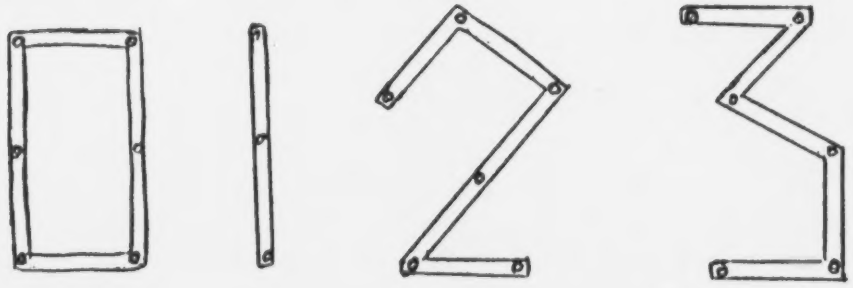
Background: An inclined plane is often used to move heavy loads up or down with less force being expended. The decrease in force expended is compensated for by the additional diagonal distance the load must travel. The factors that affect friction can be explored as children observe what slides easily and how the angle of the plank affects sliding ("dilutes" the effect of gravity).

Extensions: Ask children to try to think of places where they've seen an inclined plane in use , other than in the playground. Ask them to look for pictures of inclined planes in use -- for example, ramps for wheelchairs, slides from a moving van to the street, ramps from airplane doors to the terminal.

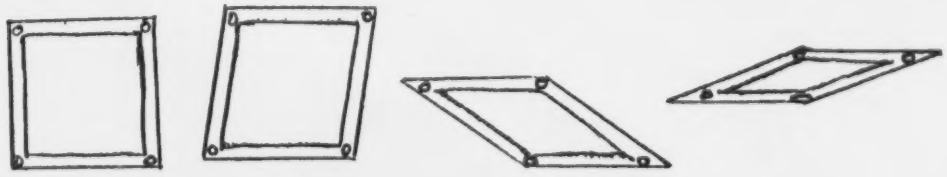


GEORULE GEOMETRY

Procedure: Show the children how to make a dynamic copy of a numeral like 3 with a georule. Have the children try to form the other numerals from 0 to 9. Some children might need to work from copies.



Talk with the children about the numerals that look different from the way they are usually written. Next have them form the letters of the alphabet with the georule and show them to a partner. (Again, classroom charts of letters can be used to help those who need this aid.) Show the class a three-sided closed shape and have them "copy it," that is, make it with three paper linkages. Have them make a four-sided closed shape with four paper linkages. Ask children to make as many four-sided shapes, different from one another, as they can by "pushing" the sides. Have students push the sides



of various shapes (three, four and five sided) so that they can observe that only the triangular shape is rigid. Talk about where some of these shapes appear in the world around us. Show pictures, such as a bird's wing and geodesic playground equipment. Show triangular shapes, other than equilateral, on the overhead projector, or with models. Have children make a list of all the triangular shapes they can find in their homes or on the way to school, and bring in pictures of as many as possible. Make a classroom display. Form a spelling list of all the objects with triangular shapes.

Materials: Georules (carpenter's ruler), linkages (equally long, stiff card-

board strips fastened with paper fasteners), straws and wire ties, or straight pins to form joints for use on the overhead.

Key Concepts, Skills and Processes

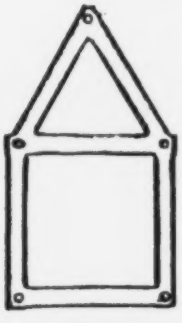
Mathematics: Concepts of angle, triangle, and quadrilateral; observing.
Science: Rigidity and flexibility in structures, observing and classifying.

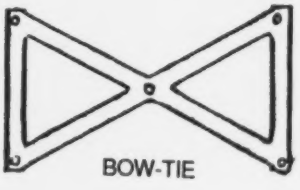
Background: These activities are designed to help develop students' spatial imagery, in particular their ability to discriminate angular shapes by having them construct dynamic models of objects, letters, and polygons. The triangle is the only rigid shape and thus is found wherever one expects strength added to structural arrangements (e.g. machines; guy wires attached to power pole; golfers addressing the ball). Primary children need to learn about the property of rigid figures by first working with flexible, angular shapes. The names of the different angle types are not important in these early lessons. The closed shapes exercise (three-sided and four-sided comparison) helps the child to recognize a physical difference between the shapes. The teacher can exploit this important property of triangles and make a direct connection to the physical world. (The georule model is a helpful way of presenting the concept of triangle, since the children can concentrate on sides and angles.)

Extensions: (1) Have students use the georule to make one of the following:

GATE

STAR


HOUSE


BOW-TIE

(2) Have them make up their own model and tell what it is. Let them use colored paper links and paste up a picture of the model on a card. (Teachers can use these to find out if other students can copy the models.)

DEW AND DEW POINT

Procedure: This activity is designed to show the children how to form dew and find the dew point of the air in the classroom. Ask one student to take the temperature of the air in the room (rounded to the nearest degree Celsius). Write it on a chalkboard temperature chart. Fill one shiny can with water from a container left standing in the room for a half an hour or more (Be sure that children know that the water in this can has been there for some time.). Insert a thermometer; have student pairs read and check each other's reading. Write the temperature reading on the board chart. Half fill a second can with the same supply of water and place a second thermometer in it. Have other students read and check the reading, as before. Record the temperature. It should be the same as the previous two readings. Ask why. Then fill this can with ice and wipe the surfaces of both cans with a paper towel to be sure they are dry. Have children observe both cans without breathing on the surfaces. As soon as droplets of water appear on the surface of the can containing ice and water, have students read the temperature of both cans. Write the readings on the board. Question students as to where the droplets of water came from, why we need two cans, why it is important not to get our breath (warm, moist) on the can and under what conditions they have noted the same or similar events in everyday life (e.g. eyeglasses "steaming up," glasses of cold liquid "sweating" during warm weather, windows of auto "fogging over" when driving in rain with windows closed and, of course, dew on the grass in the morning).

Collect feedback to be sure all know how to do the activity on their own, divide the youngsters into teams to check the dew point in various parts of the room and provide each team with two identical cans, two thermometers and a supply of water at room temperature, ice, and towels. Each group should record their estimate of dew point for their area of the room on the large prepared board chart.

Materials: Pairs of identical metal cans with labels removed (e.g. soup or bean cans), pairs of thermometers (C), ice, water.

Key Concepts, Skills and Processes

Mathematics: Using numbers, reading scales, rounding, observing, recording data.
Science: Concepts of dew, dew point, gas, liquid, changing gas to liquid, need

for control(s) in an experiment; processes: same as mathematics and also using instruments.

Background: The amount of water vapor (an invisible gas) in the air varies with atmospheric conditions, as does the dew point (temperature at which it will condense). Since metals are good conductors of heat, the surfaces of the can are essentially the same temperature as the water inside the cans. The can of water at room temperature (on which dew does not form) shows that the droplets on the other can are not leaking or "sweating" through the can and must be forming from the air. The frost that forms in ice cube compartments of refrigerators and in freezers is caused by the water vapor condensing on surfaces that are below 0^{o} C, the temperature at which water freezes. The more often we open the door, the more warm, moist air gets in. Similarly, the insides of auto windows become covered with frost (from our warm, moist breath) during very cold weather.

Extensions: The same activity can be repeated to compare the dew point in the room first thing in the morning with that at noon and at the end of the school day. Hot, humid days can be compared to cool, dry weather conditions. You may wish to have students try a water, ice and salt mixture (like the old ice cream freezer), or put moist cans in the freezer compartment of a refrigerator, in an attempt to form frost.

SAMPLE TEMPERATURE CHART

	Air in Room	Water in Can 1 No Ice	Water in Can 2 No Ice	Water and Ice in Can 2 when Dew Forms
Reading 1				
Reading 2				

WHAT IS CHANCE?

Procedure: This diagnostic activity must be conducted on an individual basis while the other children are working on something else. Lay out six red counters and two blue counters on the table, with the blue counters at the child's left. Lay out the remaining counters in exactly the same arrangement under or next to the first set, but separate these from the first set by a ruler. Have the child notice that these two sets are exactly the same. With the child watching, put one set of counters in the bag. Be sure the child realizes that the bag contains counters just like the ones on the table. Shake the bag to mix up the counters. The protocol that follows provides the script for the teacher and possible responses of the child. The teacher should not correct the child but record responses as soon as possible after the interview.

Teacher	Student Does or Says
1. "See what I'm doing? Your counters are still on the table. Mine are in this bag and I'm mixing them up."	
2. "I'm going to let you choose a counter from the bag. What color do you think you'll get? Why?"	"Color which came first" "Color I like..."
3. *Have child choose. Whatever color occurs, say:* "Why do you think you got that color? What do you think of that?"	"I guessed right. I knew it had to be"; "I don't know"; "It isn't right..."
4. *Have child place the chosen counter on the table back on the empty side of the ruler.*	
5. "Now I'm going to let you choose another counter. Before you choose what color do you think it will be? Why?"	"One I already got"; "One said before..."
Repeat steps 4 and 5 one more time.	

If it is not possible to interview all your children, interview a sample of two or three from the top, middle and bottom of the class in terms of overall past performance.

Materials: Twelve red counters and four blue counters; a bag; a long stick (ruler) to serve as a boundary between chosen counters and counters remaining on the table.

Key Concepts, Skills and Processes

Mathematics: Concepts of chance, more, less.
Science: Same as for mathematics.

Background: Since people tend to scan a horizontal row from left to right, children often predict that the color that appears first on the left will be drawn first. For the child, that color is **first** in the row and will remain **first** even when shaken with other chips in the bag. Thus, it is important to have the larger (largest in the case of three sets of colors) set of chips of one color on the right. Otherwise, children will, in the long run, be choosing the more likely color for the wrong reason. By having a duplicate set of chips facing the child, the child doesn't have to depend on memory. Thus, the teacher can find out if the child can contrast the parts with the whole. The repetition of the prediction question and the choosing activity without replacement of the chips helps the teacher to find out if the child will persist in a reason, despite the result. The teacher has to be alert to the problem of erroneous reinforcement. The child who says "Red because there are more of them" and then draws blue may be confused and invent another reason. (Even adults are prone to act surprised at similar occurrences. "There are more 9's in that game than any other number. I can't lose if I play 9." More likely doesn't mean certainty if the game is fair or the events are actually random.) Since this is a diagnostic activity, the teacher should not yield to the temptation to explain or correct the child. The concept of chance is not easy and needs to develop gradually over time.

Extensions: The Mystery Bag activity is a good follow-up to this interview activity.

Source: This activity was adapted from Piaget's *The Psychology of Chance.*

BILATERAL SYMMETRY IN OUR WORLD

Procedure: Using a large demonstration capital A on tracing paper, ask if it can be folded exactly in half. Where? Show how. Repeat with B and next try F, to show a letter where this is not possible. Distribute copies of the other letters of the alphabet to the children and ask them to try folding exactly in half so the two sides match (are congruent). Ask: "Which letters can be folded exactly in half? Is there more than one way to do this and for which letters?" Tell children that the fold is called a line of symmetry. We say that those shapes have bilateral symmetry. Show some pictures of living things (e.g. butterfly, bird) with bilateral symmetry on an overhead projector and ask children to come up and draw the line of symmetry. Show them some objects (e.g. child's hand) that do not have bilateral symmetry. Help them notice that in the real world, the two parts of the living thing on either side of the "hidden" line of symmetry (fold) are not exactly congruent.

Ask children to bring in a list of living and non-living objects found in their houses, on the way to school, or in the playground that have bilateral symmetry. They could also be asked to cut out pictures of symmetrical things and check the symmetry by folding. A collage of the pictures can be developed over time.

Materials: Copies of large, capital printed letters of the alphabet on tracing paper. (Older children can be asked to trace letters from a master sheet onto tracing paper.) Pictures of living things with bilateral symmetry and of a few common objects that do not have bilateral symmetry.

Key Concepts, Skills and Processes

Mathematics: Concepts of bilateral symmetry, congruence, one-half, mathematical model ; processes of classifying and observing.
Science: Same as mathematics and also the concept of variation in nature.

Background: If the letters being used are in standard print form, then the following have one line of symmetry, A,B,C,D,E,H,K,M,T,U,V,W, and Y; I,O, and X have two lines of symmetry. Of course, if the O is printed like a circle, then it has an infinite number of lines of symmetry. Children will need practice in checking on their ideas of symmetry by folding pictures of objects. Since one way to develop the concept of "congruent shapes " is that the shapes can be made to match exactly, then the folding process can also be used to see if

two parts of a design are congruent. However, it is possible for two parts of a design to be congruent and yet for the design **not** to have a line of symmetry. (e.g., Cut the S at its midpoint and the top part can be turned around to match the bottom part. So those two sections of the curve are congruent even though the letter S does not have bilateral symmetry. Notice that the S could not just be folded; it had to be cut.) Science depends a great deal on the concept of symmetry in classifying plants and animals.

Extensions: Use geoboards with rubber band shapes on them. Have children place a rubber band on the line of symmetry, if there is one. Have them copy the design and the line of symmetry on geodot paper for checking by folding. Children can create a symmetrical design by putting a blob of colored finger paint on a piece of paper and folding through the paint.

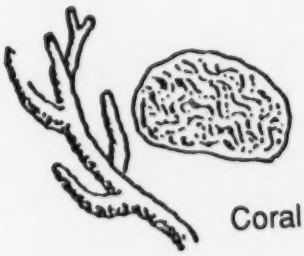
Bilateral Symmetry

Has	Does Not Have

Dragonfly

Snail

Clam



Coral

MYSTERY BAG

Procedure: Have class watch while you place 3 white and 3 black chips (marbles, same shaped attribute blocks...) in a paper bag. Keep a duplicate set of colored shapes on a flannel board (or taped to the blackboard) as a reminder of what was placed in the bag. As a demonstration, shake the bag and have a student draw a chip and show it to the class, then replace the chip. Then have the class vote on the color to be drawn from the bag; call this Draw # 1. Record the guesses (predictions) on the board. Have a student draw, show the chip, and replace it. Record the actual color drawn. Ask what color they think will occur if we draw again?" (If black is drawn first, older children who have learned by rote that the odds in this case are 1/1 may say that the next color will be white. Don't try to explain the results yet. Just ask them to continue with the activity and see if the overall results help.) Record predictions; have a child draw, show the chip to the class and record the results. Now the teacher might ask: How many times do you think we would get a white chip if we drew 8 more times, i.e. a total of 10 times? Why do you think so? Let's see what happens." Repeat the activity and stop after 10 times to compare their conjecture with the results. Have the class complete at least 20 draws and record predictions and actual results. Discuss the results and the predictions with the children, but avoid making absolute statements about what <u>always</u> happens. Work toward helping them be better predictors.

	Predictions		Results	
Draw	White	Black	White	Black
1	x			x
2	x			x
3		x	x	
Totals				

Over a period of time, do the same activity, but with 5 red chips and 5 blue chips. At a later time, use 8 blue and 8 red chips. Children need to realize that the results do not depend on the number *three,* but on having <u>equal</u> numbers. With younger children, keep numbers small and always have a reminder set in view. The reminder set can be removed with older children.

Materials: Paper or cloth bag; solid-colored marbles or chips of two different colors.

Key Concepts, Skills and Processes

Mathematics: Chance, specifically probability of two equally likely events, odds of 1 to 1.
Science: Same as mathematics.

Background: This activity is designed to introduce children to the meaning of chance in the context of a very simple case where the *empirical* probability approaches 1/2. If only 6 draws were made and the number of times that black (or white) was chosen was compared to the total number of draws (6), the results might not be 1/2. Even 20 draws is considered a small number in the real world. The concept of probability is of particular importance when considering data in science lessons, and is always associated with what happens over the long run. For this reason, teachers should resist the temptation to have students learn, by rote, the simple probability formula: number of favorable events divided by total number of events. Children need many experiences making predictions. They need to find out that what happens in the short run cannot be predicted with any accuracy, but that chance events in the long run can be predicted with some confidence (but never with certainty). In later grades, when children are taught *theoretical* probability, they should be reminded to view the computed result as what is likely to happen over the long run in the real world.

Extensions:
1. When you are confident that the children have a grasp of situations where the odds are 1: 1 (The term *odds* need not be used with younger children.), then try similar mystery bag activities with solid-colored marbles of only two colors but where the numbers are multiples of two (e.g. 3 red and 6 white) and later, multiples of three (e.g. 2 black and 6 white). Do not use more than two colors at primary grade level and do not use other combinations, such as 2 : 3 since these are usually too difficult for young children.
2. Tell the class that you have filled a bag with 6 M and M's, some brown and some yellow. They have to find out how many brown and how many yellow are in the bag by drawing one at a time (without looking in the bag), announcing the color, and replacing the candy in the bag. A record is kept of the results and 20 draws are made. Take a vote on predictions and ask for reasons before opening the bag and counting.

Source: Adapted from Horak, V. M. and W. J. Horak. (May, 1983). Take a chance. *Arithmetic Teacher,* 30 (9) : 8 - 15.

BOUNCING BALLS--A "FAIR" TEST

Procedure: Tell the students that someone told you that colored tennis balls may be easier to see, but they don't bounce as high as white ones. Ask the students to observe carefully while you perform a test to find out. Hold the white ball higher than the colored one and release the balls at the same time. Ask if they agree that the white ball bounced higher. When some point out that the test was "unfair" because you held the white ball higher, suggest redoing the test with both balls held at the same height. This time make an obvious push down as you release the white ball while letting go of the colored ball in the usual manner. When the class again identifies this as an unfair test, question them about what is required for a fair test-- an experiment, in scientific terms. Tell them to focus first on the one thing we are investigating to find out if it makes a difference--the variable of color. All other things that might change the result must be kept the same for both balls--the height, pushed down versus released with no push, etc. Tell them that the things we keep the same are called "controls" because we don't let them change during the fair test or experiment. Now ask if it would be a fair test if we kept the height and release process the same for both balls but placed a piece of carpet where one ball would bounce.

If all is going well at this point, it is time to get the students experimenting. Groups of three will work well with one student dropping a ball from a height marked on the wall while two others observe the bounce height of the first ball, mark the location on the wall and record the measured height of bounce. (Paper fixed to the wall with masking tape will protect the wall.) Suggest three trials for each ball with the middle height being accepted as most accurate. Ask why. Some student teams can work with tennis balls of various colors while others run experiments with softball versus baseball, volley ball versus basketball, etc.

Materials: Tennis balls of various colors, volley ball, basketball, softball, baseball, masking tape, paper, metric rulers.

Key Concepts, Skills and Processes

Mathematics: Concept of height; observing, measuring, comparing data.
Science: Same as mathematics and variable(s), control(s), experimenting.

Background: Youngsters will have some notions of what constitutes a fair test in real life situations with which they are familiar. (A race is only fair if all contestants start from the same place, at the same time and run the same distance.) They need help and more experiences, like this one, in order to develop into competent experimenters. Thus, keep the number of variables small and obvious, plan on providing step-by-step guidance, be patient and provide praise at every opportunity. The activity is an excellent way to help children experience the meaning of the concept of height. If older children were doing this activity, they would be asked to average the measurements, rather than to take the middle height--a developmental precursor to averaging for younger children. Intermediate-aged children could be asked to vary the height at which a particular ball is held and compare that height with the related bounce height by a bar graph. The relationship is not linear.

Extensions: Ask students to predict how high a tennis ball will bounce when dropped down an open stairwell one or two stories high and whether a volley ball will bounce as high or higher. Ask why (based on the previous data collected), and then try it. Point out that scientists always check predictions by a fair test or experiment.

DROP HEIGHT

Observed Bounce Heights

Ball 1	Ball 2
	---- 3.
1.----	
3.----	---- 2.
	---- 1.
2.----	

ANIMAL TRACKS

Procedure: Distribute copies of the page showing the footprints of some common animals. Ask the students to describe the features that allow us to tell the prints of one animal from another. Be sure that size, shape (round, oval, pointed,...), number of toes, arrangement of pads, etc. are all noted as important. Some students may have trouble perceiving differences in shape. Use cardboard containers partially filled with "Play Dough," wet plaster or mud to demonstrate how to make casts of the footprints of a pet. The teacher may need to be sure all casts are oriented in the same direction; and for some students, may need to make colored cutouts of the casts and superimpose these on one another. Have students measure width and length. Students can be given materials to take home so that each can make casts of the footprints of pets and other domestic animals in their neighborhoods. Ask that they bring these to school so all may practice identifying animals by this means. Be sure students note similarities and differences among closely related types. Introduce the term "infer" by noting that they have been making well-founded inferences based on observing imprints or casts of a key identifying feature.

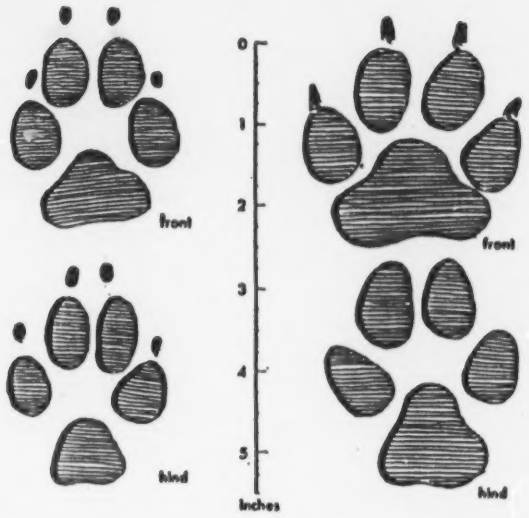
Materials: Cardboard containers (e.g. shoe boxes, cut-down milk cartons); "Play Dough," wet mud, or plaster ; metric rulers.

Key Concepts, Skills and Processes

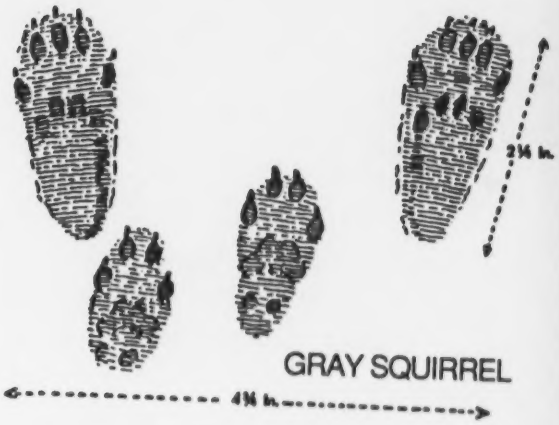
Mathematics: Measuring in metric (quantified observation), size, shape, arrangement, classifying, inferring.
Science: Same as mathematics and also identifying common animals.

Background: It is important for students to learn that well-founded inferences are important in science and in everyday life. If there were no footprints in the garden last night but it was full of rabbit tracks this morning, it is reasonable to blame rabbits for the lettuce eaten during that period of time.

Extensions: The sketches can be used on a field trip to identify a wide variety of local animals--some of which are seldom seen because of their nocturnal habits. Inferences can be made about how and where they spend their time and these might be checked by a library assignment.



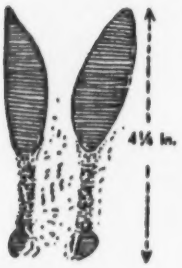
DOG



GRAY SQUIRREL

SKUNK

OPOSSUM



DEER

RACCOON

GRAY FOX

BLACK BEAR

HORSE

HOUSE CAT

BEST COPY AVAILABLE

RENEWABLE VERSUS NONRENEWABLE RESOURCES

Procedure: Hold up an apple and ask if we could ever have more apples if suddenly all existing apple trees were destroyed and this were the only apple left. Follow with "Why" or "Why not." Cut the apple in half and walk around pointing to the seeds if it is necessary to either prompt or reinforce the correct response. Next show the class a wooden ruler and ask them if there could be anymore wooden rulers if all that are in existence were destroyed. Be prepared to show a winged maple fruit (seed) if needed. Show a piece of cotton (or wool) cloth and pose a similar question. Have a picture of a cotton flower or a sheep, if needed as a prompt. Identify all of these as examples of renewable resources. We can continue to produce more of them as needed, provided we have the soil, water and air required for their growth.

Next, show pieces of coal, a bottle of oil and objects made of iron, copper and aluminum. Question as before to make the point that these are examples of nonrenewable resources. Whatever amount of them is present on Earth is all there can be. We cannot make more of them, but in some cases (as in the case of the metals) we can remake them into different objects to use a second or third time. In other words we can recycle them.

Have the students prepare charts with headings for Object, Natural Resource (what it is made of), Renewable (Yes or No), Nonrenewable (Yes or No), Scarce or Getting Scarce (Yes or No) and Can Recycle (Yes or No). Divide the students into teams to investigate all objects in their assigned part of the classroom. They will quickly find that wood and metal objects are fairly easy to deal with but that they do not know enough about the origin of paper, plaster, glass, plastic, etc. It's library research time!

You may want to assign one group to look up information about how common plastics are made while another concentrates on glass. After the group reports and follow-up questions have occurred, all should complete their charts. A concluding teacher-led discussion on the need for wise use of natural resources should make the point.

Materials: The normal assortment of objects in the classroom.

Key Concepts, Skills and Processes

Mathematics: Observing, classifying, data collecting and recording.

Science: Same as mathematics and also concepts of renewable and nonrenewable resources, recycling, and conservation.

Background: Many students fail to realize that common trees, such as the maple, oak, or beech, have flowers that produce fruits with seeds inside. These seeds, in turn, produce new trees. Lawn grasses, if allowed to grow to full height, produce flowers and seeds. Another common misconception is that plastics "appear out of thin air." Few adults, not to mention students, have any notion about the materials and energy sources involved in their manufacture. What happens to them after they are thrown in the local land fill receives about the same amount of thought. Ask the librarian to help you locate suitable reference materials.

Extensions: Repeat the project using more complex and interesting objects of study such as bicycles, automobiles, the contents of a pocketbook or the home garage, and others the students may suggest. Enlist the aid of the art teacher to sponsor a poster contest to enlighten the whole school or community. Involve the students in a survey of junk (trash) around the school--amount that can be recycled, original value, clock hours to clean up the trash. The topic can lead to questions on how to construct a simple questionnaire, how to sample appropriately, and how to depict the data. Consider inviting a knowledgeable parent to be a guest speaker.

HOW MANY ARE THERE?

Procedure: Ask the class how they would estimate the number of fish in a pond or the number of dogs in a town? Have them tell you why it is hard to get a total for each of these. Demonstrate the "tag and recapture" method with a bucket of lima beans. Show how to get a full scoop of beans and how to "tag" each bean with a red dot. Show how to mix the beans after the tagged beans have been returned to the bucket. Distribute buckets of beans, scoops, red markers, and copies of lab record sheets to each group of children. Have them complete a lab sheet to get an estimate for the total, compare their estimates and talk about differences. Direct members of each lab group to count the actual number of beans in the bucket and compare the actual result with the estimates.

Materials: A large sack of lima beans, scoops to hold 30-50 beans, buckets to hold 200-400 beans, lab sheets. Put the same number of beans in each bucket so that class can compare results.

Key Concepts, Skills and Processes

Mathematics: Counting, computing, ratio, proportion, sampling, estimation.
Science: All of the above and also uniform mixing of population.

Background: This estimation technique is based on the assumption that the tagged items (creatures) mix uniformly in the population. In a fish pond, for example, one would not tag and recapture on the same day since time is needed for the fish to distribute themselves in the pond. The mathematics involved is easy to do, but the concept of proportion is not as easy for students to understand. If 5 tagged beans are found in the next scoop of 29 beans, then there are about 6 times as many beans as tagged beans in that scoop (29 ÷ 5 is about 6). The assumption is that the ratio of tagged beans to total beans in the scoop will be the same as the ratio of all tagged beans to all beans in the bucket. So, if 50 beans had been tagged and replaced, there would be 6 x 50 or 300 beans estimated to be in this bucket.

Extensions: Average the estimates of all the lab groups and compare the average result, also an estimate, with the individual estimates.

Source: Adapted from O'Daffer, P. and R. Souviney. (February, 1986) Problem solving tips for teachers. *Arithmetic Teacher*, 33: 56-57.

Lab Sheet for Tag and Recapture

1. Count the beans in this scoop. _____.

2. Tag each bean from the scoop.

3. Return all the tagged beans to the bucket and mix well.

4. Take out a full scoop without looking into the bucket. Count the total number of beans and the number of tagged beans in that scoop.

In The Scoop

Total number of beans ___ Number of tagged beans_____

5. Use the calculator to divide the total number of beans from the scoop by the number of tagged beans and round to the nearest whole number. Result_____.

6 Multiply the result from step 5 by the number of tagged beans from steps 1 and 2. Result _____
(Check your multiplication with the calculator.)
This result is an estimate of the number of beans in the bucket.

THE ULTIMATE ICE CUBE CONTAINER

Procedure: Place some ice cubes on a cafeteria tray and walk around the room while asking the class to predict what will happen to the cubes, how long they think it will take and what they think causes this event. Pick up one of the cubes, close your hand around it and ask if that cube will melt faster or slower than the others and why. Then ask "What is the fastest way to put a stop to the melting?" and "How do we make more ice cubes?" Now pose questions on how people obtained ice for home use and how they kept it from melting in the days before the invention of freezers and refrigerators. Elicit whatever ideas the students have and then ask them to question grandparents and other adults on the subject and bring in this information the following day. Announce tomorrow's contest: To find out who can build the best ice cube container--one that will prevent the cube from melting for the longest time. Invite students to bring in materials they would like to use in their construction of containers. Meanwhile, pass out metric rulers, paper towels on cafeteria trays and fresh ice cubes. Have students note the time, measure the cube at given intervals until melting is complete, and record these data in a table. During the measuring and recording of data remind the students that these pieces of ice are not really cubes and may vary considerably from a mathematical cube depending upon the tray in which they were made.

On the day of the big contest have available a variety of insulating materials to supplement what the students may bring in from home. Question the students on what they learned from their grandparents and other adults, and how this information might guide the design of the best container. Divide the students into teams of two or three boys and girls. Tell them that each team must make three identical containers, each one to hold an ice cube. One is to be opened and checked periodically until its ice is melted. Then the procedure is to be repeated with the second container and then, with the third container. The official time to be recorded is to be that of the melting time of the ice in the third container. Ask the students to explain why this is a good rule. Point out that you are going to give each team three ice cubes of the same size and shape and ask why this is important. (A "fair" test requires that all things be the same, *controls*, except for the one thing we are investigating, the *variable*.) Tell them they must show you a sketch of the container they plan to construct prior to starting work.

Remind everyone about the data on melting collected yesterday, use it to select the time interval for checking on melting. Distribute the ice cubes and

begin the activity. Other lesson segments can go on during the time between the periodic observations. Discuss the geometric solids represented by the ice *cubes*, the construction of ice chests taken on picnics, the construction of thermos bottles, differences between summer and winter clothing, and insulating materials used in home construction. Either during or after the data gathering, each team should make a brief presentation describing and explaining the construction of their container.

Materials: Paper cups, drinking glasses, plastic baggies, styrofoam (cups and lids, packing "peanuts," scraps), pieces of cardboard, scraps of cloth, milk cartons as well as whatever students may bring to class, large clock.

Key Concepts, Skills and Processes

Mathematics: Measuring (length, time), data gathering, preparing data tables, geometric shapes used as mathematical models, congruence, variable.
Science: Same as mathematics and also predicting; and concepts of heat loss and gain, energy, melting (solid to liquid), freezing (liquid to solid), controls, designing a "fair" test(experiment).

Background: There is no such thing as *cold*. Cold is a comparative term meaning lack of heat. Nor is *heat* a thing or substance. It is a form of energy associated with the movement of molecules within a substance. That is why the vacuum in a thermos bottle is such a good insulator, very few molecules to transfer heat energy. One must use judgment in how far to carry these distinctions with youngsters. However, you should insist on "heat goes from the air (hand, food, etc.) into the ice and causes it to melt" rather than "the cold goes from the ice into the soda (air, tray, etc.) and cools it down." This is a common misconception among adults, even in the case of college graduates who are not science majors. Let's be patient with the youngsters while building a solid foundation for future learning in the junior-senior high school! Note also that the ice "shapes" from the same tray (except for the ends which are often rounded more than the others) are real world examples of congruent shapes. Like all examples, they are not **exactly** congruent.

Extensions: Have the class get data on the melting rates of a whole vs. a smashed ice cube (much more surface of ice exposed to the warmer air). Direct students to collect ads for heat insulating materials and discuss how each is designed to perform its function.

LENGTH OF A BEAN SEED

Procedure: Walk around the room holding up a bean seed and ask the students to estimate its length in mm. Then measure the seed, while demonstrating correct techniques, and compare the actual measurement with the range of estimates. Next, ask them to predict whether or not all bean seeds from the same package would be the same length. To check the predictions, divide the students into pairs to get the data. Remind them of the correct techniques and distribute the materials. Tell them to record each measurement, rounding to the nearest mm, and place the seeds on graph paper in columns sorted by size in order of smallest to largest (left to right). Demonstrate this with a sketch on the chalkboard and instruct each pair to gather data on at least ten seeds. When the first few pairs finish, have them tape their seeds to the graph paper (with scotch tape) in histogram style. Show these to the rest of the class, while discussing the data and its meaning. Complete the activity by combining all class data and representing it on a large histogram drawn on the chalkboard. Question the students on the skills , processes and concepts developed.

Materials: Bean seeds, metric rulers, 3x5 cards, graph paper.

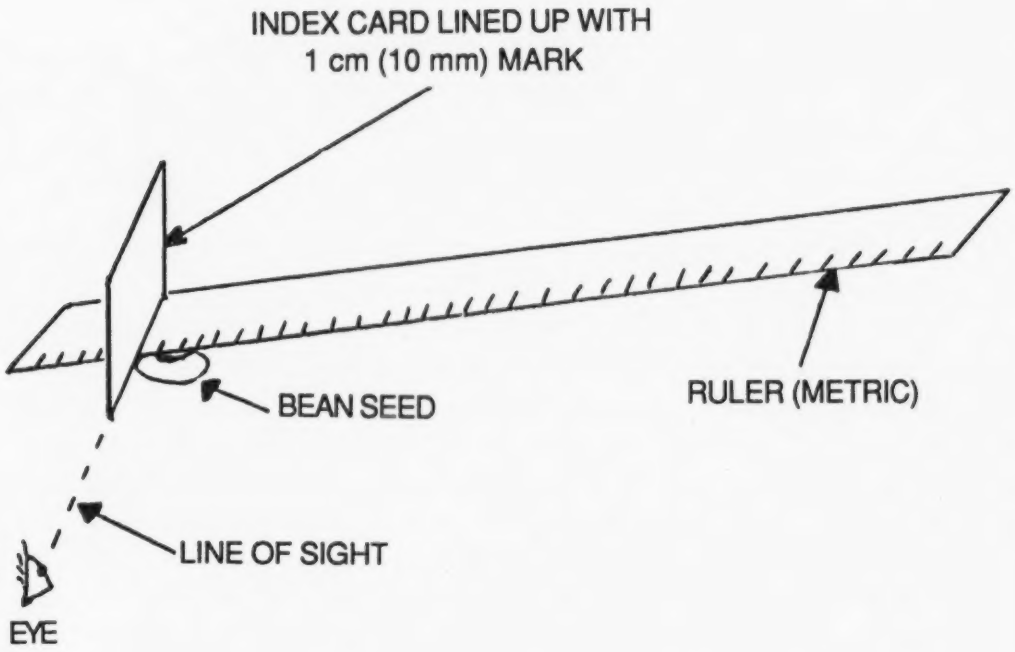
Key Concepts, Skills and Processes

Mathematics: Measuring in metric (quantified observation), estimating, rounding, averaging, classifying, predicting, data gathering, and concepts of range, histogram, and normal curve of variation.
Science: Same as mathematics and also variation in nature.

Background: Some important measuring techniques include not using the end of the ruler (which may be worn), using 3x5 cards to help line up eye and ruler marking at the end of the object being measured, and taking three readings and using the average. It is also important to point out that predictions must always be checked out by gathering relevant data and that variation, not absolute uniformity, is most often the rule in nature. Identify this pattern as the normal curve of variation. Displaying these data in the form of a histogram is appropriate because the data vary continuously throughout the range from lowest to highest measurement--otherwise a bar graph (with spaces between the bars) would be correct. Teachers should note that length, width and height are not always easy to identify. For instance, in measuring the width of an egg, it depends on how it is held or arranged in a

container. Finally, caution students about putting seeds in their mouths. Seeds intended for planting, but not eating, are often coated with poisonous chemicals to prevent the growth of molds.

Extensions: Ask the students to suggest other things that may vary more than most people think. Some likely objects, whose lengths may vary, include eggs from cartons labeled "medium," leaves from the same tree, index fingers of students in the same class, unused crayons from the same box and heights of all fifth grade girls or sixth grade boys. Only imagination and practical concerns limit the possibilities. Students might well be asked to gather some kinds of relevant data at home and display their results in the classroom.



TWIG GROWTH

Procedure: Make an overhead transparency of the sketch of a typical woody twig. Show it to the class while pointing out such key features as terminal (end) bud versus axillary (side) bud and the terminal bud scars from earlier years vs. the leaf scars. Point out that the terminal bud overwinters and sprouts the next year's new growth in the spring. Distribute the materials and direct the students to tell the age of each twig and measure the growth length for each year (nearest mm). Each student should measure several twigs of various kinds of trees and record these data on a chart. Then compile the data from all the charts and ask questions such as "What factors (variables) might account for the fact that the amounts of growth differ for (1) the same twig in different years, (2) twigs from different trees of the same kind during the same years and (3) twigs from different kinds of trees."

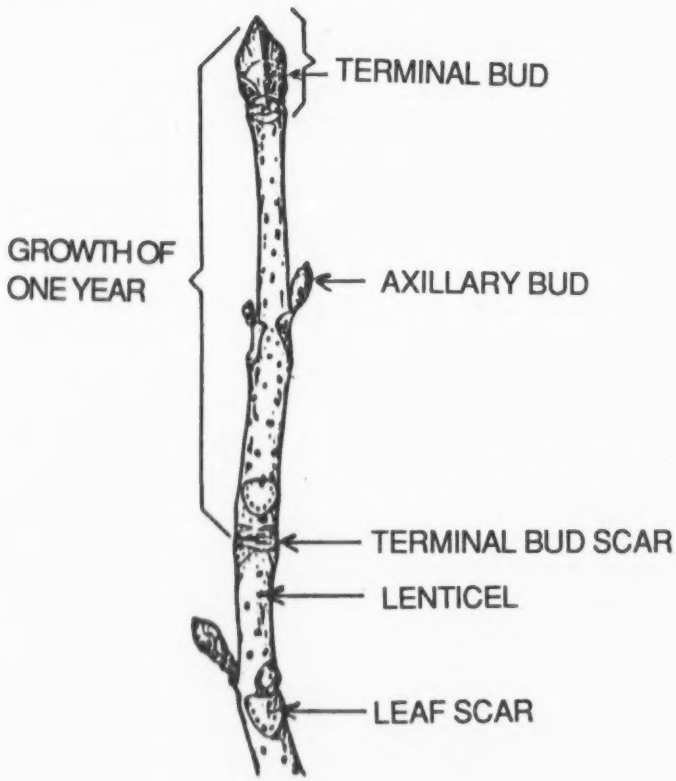
Materials: Metric rulers, hand lenses, copies of the sketch of a typical woody twig, twigs from a few different kinds of local trees (several from each kind and try to include horse chestnut, as it is the easiest to age).

Key concepts, Skills and Processes

Mathematics: Measuring in metric, data gathering, identifying by size and shape.
Science: Same as mathematics and also concepts of growth and variables; factors affecting rate of tree growth; process of inferring; skill of using instruments (The hand lens is an instrument--a device which serves as an extension of the human senses).

Background: Important variables in the rate of tree growth include availability of water, sunlight and minerals during the growing season. A late spring frost may kill the sprouting terminal buds or damage recently sprouted tissues. Tender buds and new growth also are attractive food for Whitetail deer. Nearby tall trees may block sunlight from shorter neighbors while trees on steep, well-drained slopes are the first to suffer from lack of water.

Extensions: If an increment borer can be borrowed from a high school science department or a forester, students may use it to study core samples of tree trunks for evidence of cross-sectional growth rates over many years. The lender should be able to demonstrate its use.


TERMINAL BUD
GROWTH OF
ONE YEAR
AXILLARY BUD
TERMINAL BUD SCAR
LENTICEL
LEAF SCAR

FORM AND FUNCTION IN THE ANIMAL WORLD

Procedure: Fish and birds are common examples of the general rule (principle) of the natural world that form and function are closely related. Gather whatever live specimens, models, pictures and parts that are locally available. Remind (inform) students that animals that have survived have learned how to: (1) get food (eat), and (2) survive without being eaten (two basic necessities for survival). Display the collection and ask the students to describe the adaptations of fishes and birds that contribute to the solution of these two basic problems. Each time the students point out an adaptation (hooked beak, hollow bones, large chest muscles, streamlined shape, fins, feathers, coloration, ...), ask for specifics regarding how each increases the chances of getting food without in turn being eaten by another animal. Point out that animals that kill and eat other animals are called *predators*.

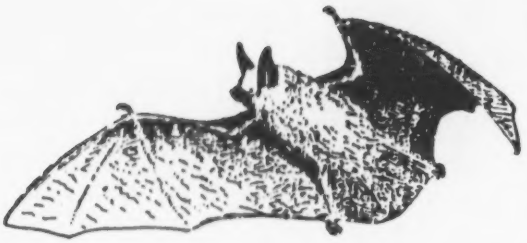
Materials: Try to include live fish of several kinds (students may be able to bring in some from home), a chicken or turkey carcass left over from a Thanksgiving dinner, stuffed specimens (borrowed from parents who hunt or fish), models showing details, feathers, pictures of birds and fish including some in their natural surroundings.

Key Concepts, Skills and Processes

Mathematics: Observing, size, shape, arrangements in patterns, inferring.
Science: Same as mathematics and also feeding and locomotion, adaptations in animals, protective coloration/patterns, form related to function.

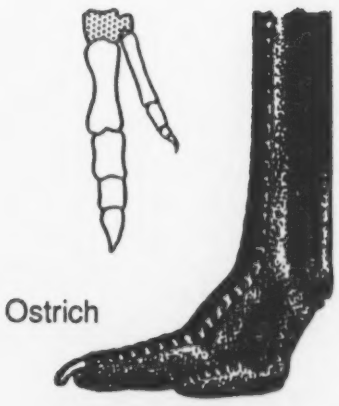
Background: The "white meat" on a chicken (or turkey) is the well-developed flight muscles of the bird and the large "breast bone" is where these are attached to the skeletal system. Many fish and birds have dark colors along the backbone side and light colors on the under side. Predators hunting them from above see dark against a dark background while predators attacking from below see light colors against the light colors of the sky. Also be sure to call attention to how patterns or markings on the body would be seen against the natural surroundings of the specimen.

Extensions: Repeat the lesson using mammals as subjects. Bring a guest speaker from the local bird watchers' club for a presentation on the beaks and feeding habits of common birds. Take a trip to a natural history museum.



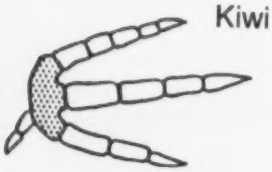
Long-eared Bat

Beaver



Ostrich

Ostrich feet are highly adapted for running. By contrast, the kiwi's foot is far less modified.



Kiwi

PROBABLY SO, BUT POSSIBLY NOT !

Procedure: Tell class that you have prepared bags of M and M's with the four colors (yellow, brown, orange and green). Each bag has the same number of each of the four colors. The students' job will be to see how good they are at predicting how many M and M's of each color are in the bag without looking and without being told the total number of candies in the bag. With a demonstration bag, show how to shake the bag (without spilling the M and M's). Stress that they should not look in the bag. Show how to choose one M and M quickly (No fair trying to use the sense of feel to conjecture the total number of candies). A partner should record the color and then return the candy to the bag, which is shaken again. Now the partner chooses and the process is repeated. Show on a sample chart on the board or overhead how to record tallies.

Have each youngster write a guess as to which colors there will be most of and which least of. Tell them to fold the paper with the guess on it until after the laboratory activity. Tell each pair of children to prepare a chart like the one on the board, while the bags of M and M's are being distributed. Walk around the room to be sure that instructions are being followed. When the groups have finished drawing (at least 40 times), have them total the results for each color. Ask: "Now which color do you think there were most of?" Record votes on the board. Ask: "Which color do you think there were least of?" and again record votes. Have the class compare results. "Which of the other two colors do you think will be second highest in number?" Tell the children to open the bags, count the candies and compare the results with their draws and their predictions. (For older children who have worked with the probability formula, have them compute the *theoretical* probability of drawing each color. Compare these *theoretical* probabilities with the *empirical* probabilities.) Talk about differences and similarities between results and predictions and emphasize the concept of chance. Have the children share their first guess about the most and least colors with their partner. Ask if the results were what they expected. Emphasize the difference between seeing and observing.

Materials: Paper lunch bags, one for each pair of children in the class; enough M and M's to place 10 brown, 4 yellow, 4 orange and 2 green in each lunch bag.

Key Concepts, Skills and Processes

Mathematics: Chance, empirical probability of four events, not all of which have an equal chance of occurring; skill of tallying data and recording tallies in a chart; process of inferring from the data.
Science: Same as for mathematics and also, seeing versus observation, and the concept of sampling.

Background: Most, if not all, children have enjoyed M and M's. Yet the results of this activity usually show that what we see, we don't necessarily observe. The use of four colors tests the understanding of children who have no difficulty with probability as long as only two variables are involved. The numbers of each color suggested in the Materials section gives two colors that are equally likely (yellow and orange), both of which are twice as likely as green. With 40 draws for each pair of children, it is probable that brown will be drawn the most in each case. It is quite possible that yellow and orange will not be drawn an equal number of times, even though their *theoretical* probabilities are equal, 4/20 or 1/5. The number of each of these colors is relatively small and very close to the number of green candies. This kind of result is a good example of the difference between the probable and the possible. The activity is also an introduction to sampling and sampling problems. In many cases, scientists must depend on sampling as opposed to counting.

Extensions: The teacher may want to total the data for all pairs, either during the same class or after collecting the records, in the next class. Then the total number would be considerably larger and the class could talk about the effects when the number of draws is increased dramatically. Different ratios of four colors of marbles or poker chips can be used at another time. However, it is recommended that the ratios be kept relatively simply (e.g. 2:1 or 3:1) and that estimates, rather than an exact answer, be emphasized. Have the children list other examples of this kind of sampling (e.g., gumball machine games, bingo). Have the children talk about other examples of what is possible and what is probable (e.g. 90% chance of rain today. It will probably rain but it is possible that it won't rain.)

Procedure: Show students two, large, clear, colorless plastic soda containers (with necks cut off at the shoulders). Fill one with water to the 2 liter mark and call attention to the other gradations marked on the container with magic marker. Place the larger sized rocks in the other container until it is "filled" to the top. Ask if this container is now "full" of rocks. When the students point out the "empty" spaces, display the small pebbles (or marbles). Pour these in while banging the container on the table to settle material into the spaces. Again, question the students about the "fullness" of the container of rocks and pebbles (or marbles). Then add dry sand and tap the container to distribute the sand as thoroughly as possible into the remaining spaces. Point out that we have created a good model of what the Earth beneath our area is like -- a mixture of large and small rocks with sand and soil materials. At this point ask if all the spaces have been filled. Some may suggest that there might be some room for a little water. If not, suggest the possibility and elicit predictions of how much. Record the predictions and then slowly add water to "fill" the container and record the amount. Make the connection to rain and melting snow seeping into the ground and being stored in all those "too-tiny- to- see" spaces. Question the students about water wells and their importance in tapping this ground water for use in city as well as in rural areas.

Materials: Two clear, colorless plastic soda containers (2 liter), large and small rocks or marbles, gravel, etc. of suitable size for the container, dry sand, magic marker to mark the water container gradations.

Key Concepts, Skills and Processes

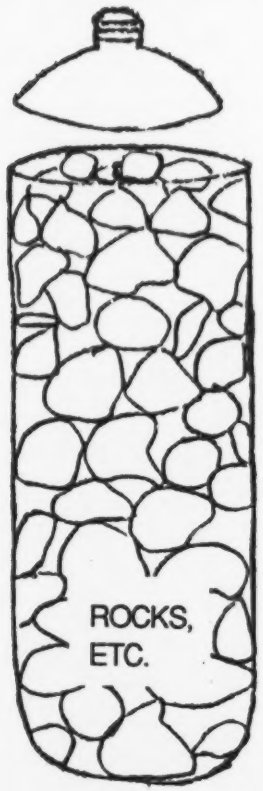
Mathematics: Concepts of capacity (volume) and space; processes of estimating volume and inferring.
Science: Same as mathematics and also concepts of soil structure, ground water, water supply.

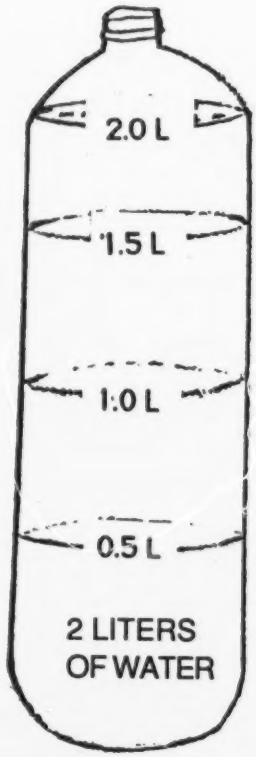
Background: The concept of volume is one with which students at this level need more experience. (Even older students who can compute volumes of rectangular solids have been found to have little idea of the relationship of the final product to the interior space.) Also, they will need reminding that the spaces observed were really full of air, as were the "empty" containers at the start of the demonstration. Note how the demonstration proceeded from

the obvious (large, easily visible spaces) toward the much less obvious (evidence for spaces too small to be visible to the human eye). A common misconception is that wells are typically deep holes drilled into underground lakes.

Extensions: Have students research information about the water supply systems that serve homes and industries in the local area. All high school earth science textbooks contain sections on ground water and wells. One or more students with artistic skills might enjoy preparing a cross-sectional diagram of a well for class use. For further work on developing the concept of volume in the form of liquid capacity, use several containers of different shapes (different heights, different widths,...) but all holding the same amount of liquid. Pour colored water into these, one at a time. Have students estimate whether there is more water or less water in particular containers. Let them check their predictions by "measuring" the water into a common container.

CUT OFF TOP AND SHOULDERS





SOAK BOTTOMS IN HOT WATER. THEN TWIST OFF BLACK COVERS.

LEAF SHAPE and ARRANGEMENT

Procedure: Display a wide variety of plant specimens demonstrating differences in leaf shapes and arrangements on the stems. Call attention to the fact that leaves make food **ONLY** if they (1) receive sunlight and (2) obtain a sufficient supply of water from the roots. Stand above a relatively short garden plant and look down. View a houseplant from the side. Ask students to do the same and think about the mathematical shapes they see. Ask how each shape is adapted to ensure maximum exposure to sunlight and how arrangement facilitates rain water being directed to the root system. Distribute actual specimens to each working group and invite each team to make a model of an ideal situation. Reinforce the notion that ideals are seldom achieved but often approximated in the real world. Distribute materials and let the students begin. Meanwhile, make a few of your own models and let the students know you are doing this. Ask students to suggest advantages and shortcomings of each model. Use a sprinkling can to help settle arguments.

Materials: Plants of all varieties with differently shaped leaves and with varying arrangements of leaves on the stems, construction paper, pipe cleaners, plastic tape, glue, magic markers, sprinkling can.

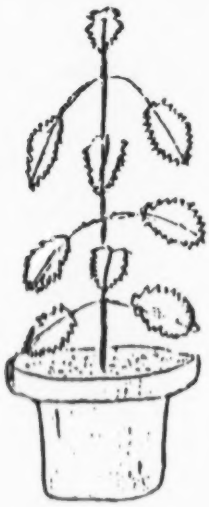
Key Concepts, Skills and Processes

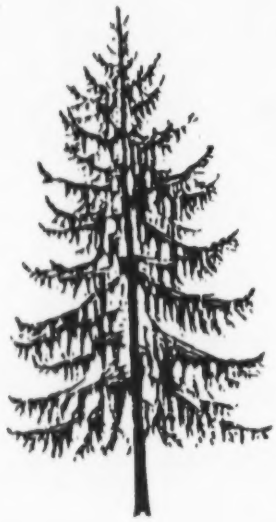
Mathematics: Shape (e.g. toothed, rounded, parallel-sided or elliptic), arrangement (adjacent, alternating, opposite), model (ideal).
Science: Same as mathematics and also concepts of shape (form) related to function and related to survival; the principle that essentials for growth and survival of green plants include sunlight and water.

Background: Take a second look at the world of nature that surrounds all of us. Sit underneath a tree and look upwards. Notice that the branches are arranged in ways that allow rainwater to be deflected from upper to lower branches and thus, to the roots. Similarly, leaf shape and arrangement of leaves on branches affect the filtering of sunlight from upper to lower leaves. The key idea is that those plants with the forms that allow them to compete successfully for the essentials of life survive and pass those traits on to their offspring (via reproduction). Those not so adapted either die prior to reproducing or pass on forms that do not lead to survival of the offspring. Make a list of the shape terms from a source such as Petrides' *Field Guide to*

Trees and Shrubs .

Extensions: Ask parents to loan their favorite house plants and/or to come to class and talk about them with respect to the objectives cited earlier. A field trip to observe local trees would be an excellent follow-up activity, as would a field trip to a museum of natural history. Invite mathematics and science "specialists" from the junior/senior high school to accompany you and offer suggestions. It's likely that all will learn from each other and the experience.





(Illustrations not to scale.)

SOURCES OF FURTHER IDEAS

Professional Journals

The Arithmetic Teacher, a journal of the National Council of Teachers of Mathematics, Reston, VA.

Each issue has key articles and "Ideas" sections for primary and intermediate grade classes. The emphasis is on hands-on activities and easy-to-obtain materials. Developmental lessons and diagnostic lessons can be found in almost every issue.

School Science and Mathematics, a journal of the School Science and Mathematics Association, Bowling Green, Ohio.

Each issue contains articles on mathematics or science teaching, learning, curriculum, or research at various grade levels. Recent journals have included a column devoted to the interaction of mathematics and science in the classroom.

Science and Children, a journal of the National Science Teachers Association, Washington, D.C.

This journal focuses on the K-6 grade levels and is loaded with "how-to-do-it" type articles written by elementary teachers and teacher education professors interested in these levels. Any single article is likely to contain ideas for several related lessons and the use of readily available materials is emphasized.

** (The only weakness we find in these journals is that authors tend to highlight only the mathematics or science potential of an idea (with the exception of the column, SSMILES, in School Science and Mathematics). We recommend all of them highly. Be sure that your school library subscribes to these. Better yet, start your own subscription.)

Teacher Idea/Reference Books

Abruscato, J. & J. Hassard (1977). The whole cosmos. Santa Monica, CA: Goodyear Publishing Co.

Biggs, E. E. & J. R. MacLean (1969). Freedom to learn. Reading, MA. Addison-Wesley.

Elliot, H. A., J. R. MacLean & J. Jordan (1968). Geometry in the classroom. Toronto, Canada: Addison Wesley.

Dumas, E. (1971). Math activities for child involvement. Boston, MA: Allyn & Bacon.

Herbert, D. & H. Ruchlis (1968). Mr. Wizard's 400 experiments in science. Brooklyn, NY: Book-lab.

Hone, E. B., A. Joseph & E. Victor (1971). A sourcebook for elementary science. New York: Harcourt Brace Jovanovich, Inc.

Petrides, G. (various dates). Peterson field guide series. (birds, trees, animal tracks, etc.) Boston, MA: Houghton Mifflin.

Schmidt, V.E. & V. N. Rockcastle (1968). Teaching science with everyday things. New York : McGraw Hill.

Time-Life Books. (various dates). Life science library and life nature library. (Volumes on fish, birds, energy, mathematics, machines, the human body, the sea,etc.), New York: Time, Inc.

Curriculum Projects

Developing Mathematical Processes. New York: Rand McNally.

New York Energy Education Project. Contact Dr. Dale Westcott, Guilderland Middle School, State Farm Road, Guilderland, NY 12084, for information.

Nuffield Mathematics Project. New York: John Wiley.

Science: A Process Approach (SAPA). New York: Rand McNally.

Science Curriculum Improvement Study (SCIS), University of California, Berkeley.

School Science and Mathematics Association, Inc.

Darrel W. Fyffe, Executive Secretary (1981-90)
126 Life Science Building
Bowling Green State University
Bowling Green, OH 43403-0256
(419) 372-7393

Errata

Farmer, Walter A. and Margaret A. Farrell. (1989). Activities for Teaching K-6 Math/Science Concepts. Bowling Green, Ohio: School Science and Mathematics Association.

The following page addition and corrections are presented:

a. corrections to the References and

b. addition of the Usable Junk page.

Biggs, E. E. & J. R. MacLean (1969). Freedom to learn. Reading, MA. Addison-Wesley.

Elliot, H. A., J. R. MacLean & J. Jordan (1968). Geometry in the classroom. Toronto, Canada: Addison Wesley.

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Schmidt, V.E. & V. N. Rockcastle (1968). Teaching science with everyday things. New York : McGraw Hill.

(Various authors). (Various dates). Life science library and life nature library. (Volumes on fish, birds, energy, mathematics, machines, the human body, the sea,etc.). New York: Time, Inc.

(Various authors). (Various dates). Peterson field guide series. (birds, trees, animal tracks, etc.). Boston, MA: Houghton Mifflin.

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Nuffield Mathematics Project. New York: John Wiley.

Science: A Process Approach (SAPA). New York: Rand McNally.

Science Curriculum Improvement Study (SCIS), University of California, Berkeley.

USABLE JUNK

Alphabet stencils
Attribute blocks
Bags and baggies (plastic)
Balloons
Balls
Batteries
Boxes (cardboard, plastic)
Bolts and nuts
Bottles (glass, plastic)
Candles
Cans
Cards (index)
Carpenter's ruler
Cartons (milk, tissue)
Clay
Cloth
Clothes pins (pinch)
Coat hangers (wire)
Computer paper (pinfeed edges)
Corks
Cotton
Crayons
Dishpans (plastic)
Eye droppers
Fishline
Flashlight bulbs
Flower pots
Foil (aluminum)
Funnels
Glass (flat pieces)
Globe (model of Earth)
Household chemicals(such as alcohol, ammonia water, baking soda, food coloring, iodine, lemon juice, mineral oil, salt, sugar, vinegar)
Inner tubes (auto, bike)
Jars (screw-top and a gallon wide-mouth)
Leaves (dried and pressed, laminated)
Magic markers
Magnets
Magnifying glasses
Marbles (solid-colored and mixed)
Mirrors (plane, curved)
Nails
Needles (sewing)
Pails (plastic)
Paper (construction, graph)
Paper clips, fasteners
Pipe cleaners (various colors)
Plastic covers from cans
Plastic wrap
Poker chips
Razor blades (single edge)
Rulers (metric)
Sawdust
Scissors
Screws
Seeds
Soda straws
Soil (sand, loam, ...)
Straight pins
String
Stoppers (rubber)
Styrofoam (cups, sheets)
Tape (masking, scotch, adding)
Thermometers (Celsius)
Tongue depressors
Tools (saw, hammer, tin snips,...)
Tubes (cardboard from waxed paper or food wrap, also rubber and metal tubes)
Vermiculite
Washers (metal)
Waxed paper
Wire (salvaged from old radios, TV sets)
Wood (all kinds, sizes and shapes)
Yarn (various colors)

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